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Event-Based Through-Life Cost Management

Robert A. Butler
TFD Group

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Overview

- Cost modeling methods
  - For system-level estimation, budget forecasting and engineering decisions
  - Recent advances in activity-based costing and event-based methods

- Methods follow use

- Problems with mixed methods

- Event-based cost modeling

- From through-life costing to budget forecasting

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Cost Modeling Methods

- Spreadsheet calculations
  - Chart of accounts

- Models based on parametric equations

- Engineering cost models

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Spreadsheet Methods

- Flexible, fast and simple (sometimes)

- Change to meet each new requirement

- Conceptual errors

- Usually one-time devices

- Normally only used for short-term costs

- Emphasize the organization of costs (chart of accounts or cost breakdown structure)
  - By budget category
  - By time increment

Models Based on Parametric Equations

- Appear simple to the final user

- Are actually very complex

  - Require extensive research to develop parameters

- Theory often suspect

  – Extrapolation is risky

  – Best at forecasting if you intend to repeat past mistakes, i.e., when context doesn't change

  – Assumes that observed systems belong to the same "class" as the system under study

- Cannot be used for design

  – Conclusions are opposite of intended: e.g., weight

Engineering Models

- Depend on hardware characteristics
  - Failure rates, average repair time, unit prices…
- Respond to programmatic data
  - Fleet size, deployment, op tempo…
- React to support structures and performance
  - Echelons, repair fractions, delay times…
- Can be used to study cost impact of
  - Hardware characteristics
  - Programmatic plans
  - Support structures
  - Support performance

Recent Methods

- ## Activity-based costing (ABC)
  - Reacts to the desire to base budget requirements on operations rather than historical precedent
  - Probably originated with zero-based budgeting initiatives

  - Drawbacks
    - Lack of repeatability
    - Labor-intensive nature of the analysis

Recent Methods 2

- Event-based analysis
  - Originated on LPD 17 ship competition
  - Requirement to distinguish between very similar main propulsion engines
  - No time for parametrics, which couldn't have distinguished the differences in any case
  - Extended earlier ideas about isolating "maintenance events"
    - To account for both scheduled from unscheduled maintenance actions
    - By decomposing failures into failure modes with different resource demand implications

Method Follows Use

- Acquisition cost analysis
  - Method: Parametrics
  - System-level focus
  - Emphasis on time and budget categories
- Budget forecasting
  - Method: Spreadsheets
  - More recently, activity-based costing (ABC)
  - Activity-level focus (budget line item holder)
  - Emphasis on time and budget categories

Method Follows Use 2

- Engineering design
  - Method: Simple accounting or engineering models
  - Subsystem and lower focus
  - Emphasis on net present value

- Logistic resource requirements
  - Method: Rich, data-intensive engineering models
  - Program focus
  - Emphasis on mean quantities

Mixed Analytical Methods

- The use of cost estimates persists throughout the life of a system

- Each analytical method appears to have advantages for a specific type of decision

- But all uses of analysis are linked to each other
  - For specific events (e.g., milestones)
  - For specific decisions (e.g., choice of tenderer)

- Different uses of analytical methods are also interwoven in time
  - Midlife upgrades impose acquisition decision processes on the management of an in-service system
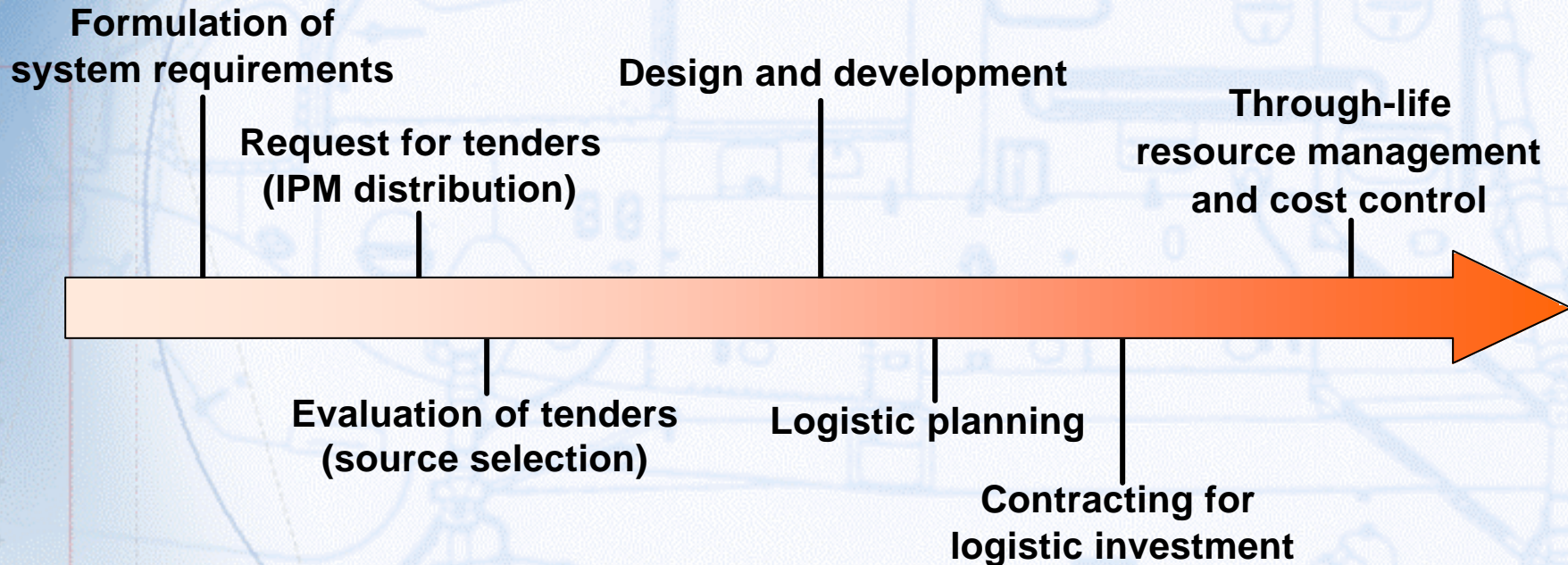
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- None of the methods communicates either inputs or outputs to the other methods

- Results:
  - Analytical effort is dominated by data collection, organization, cleansing and formatting
  - Inconsistency of inputs means costly repetition of the data collection tasks
  - Inconsistency of methods (and data sources and data treatment) leads to inconsistency of outputs
  - Decisions based on analysis are, in turn, inconsistent
  - ***Decision-makers soon lose confidence in the utility of* any *analytical process***

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An Enabling Solution

- Unified or consistent methods that avoided data steps would
  - Save significant labor devoted to data collection
  - Put analytical results in the hands of decision-makers sooner
  - Preserve consistency of data supporting decisions
- To address all uses requires special capabilities for a cost methodology
  - Speed
  - Accuracy
  - Modeling response to changes in system attributes
  - Modeling response to policy variables (variables in the decision space of system managers)

MAAP is Useful Throughout the System Life Cycle

- Event driven TOC
- Use across Life Cycle

Formulation of system requirements

Request for tenders (IPM distribution)

Design and development

Through-life resource management and cost control

Evaluation of tenders (source selection)

Logistic planning
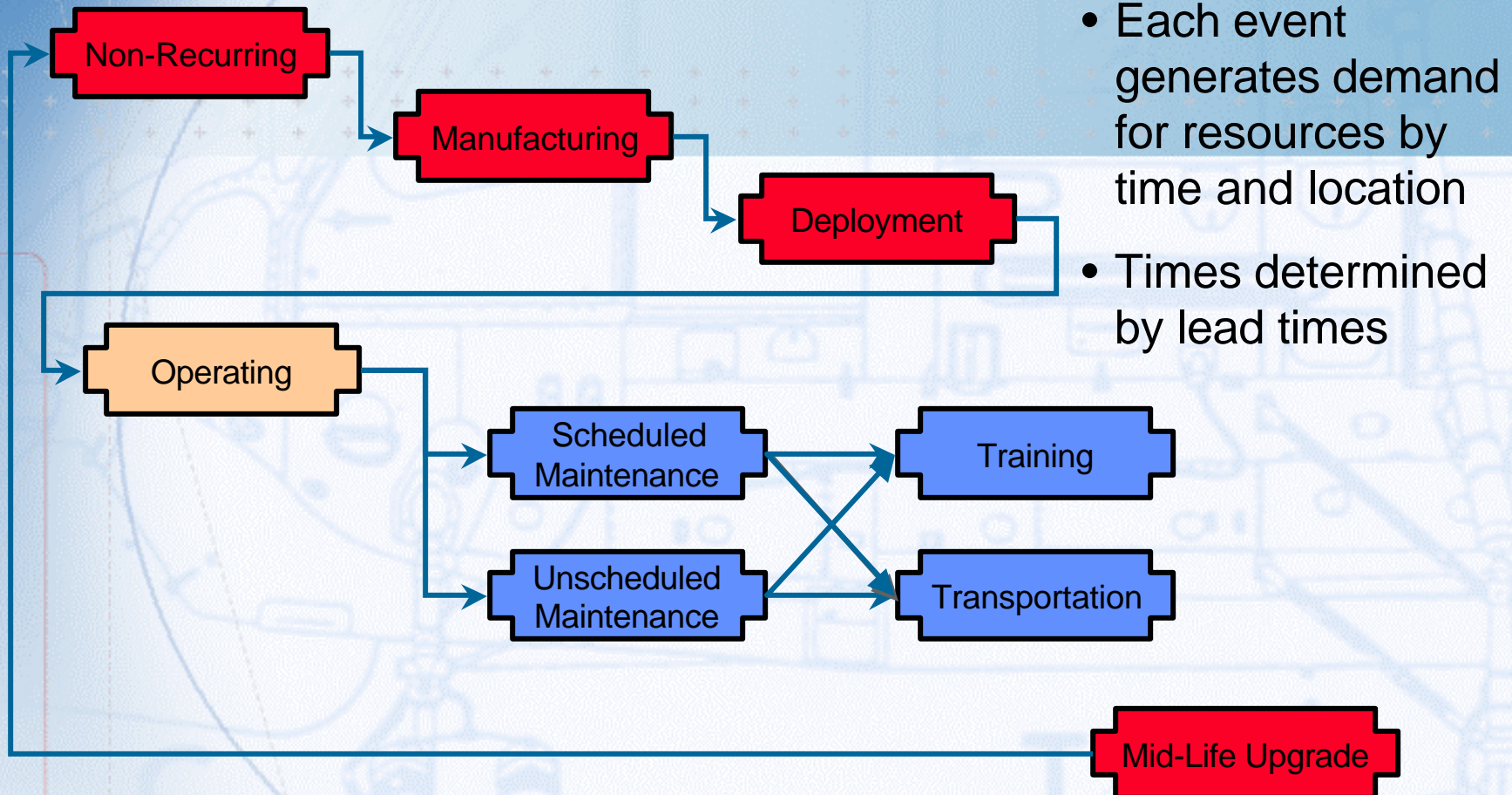
Contracting for logistic investment

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Event-Driven Cost Analysis with MAAP

- An engineering model whose costs are influenced by changes in system attributes
  - Reliability
  - Maintainability
  - Production or purchase cost

- These attributes, in turn, influence
  - Operational capability
  - Support effectiveness
  - Logistic requirements
  - Cost of production, support and operation

- -- when they are combined with a description of the operating and support regime in which the system will be (is) fielded

The MAAP
Event Analysis Engine

- An event is a cost-generating element of the "future history" of any hardware component

- The component's future history is described by a variety of events:

  - **Non-recurring** and **manufacturing events** cause systems to be created and deployed

  - **Operating events** cause systems to acquire operating hours at sites in time intervals

  - Resulting component operating hours and the passage of time give rise to **maintenance events,** which, in turn give rise to **training**, **transportation** and other types of events

- Events result in the consumption of resources – by location and time – which in turn requires their acquisition (in prior time periods), transportation to the location of use and maintenance or replacement after use

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How MAAP Computes Whole Life Costs

Non-Recurring

Manufacturing

Deployment

Operating

Scheduled Maintenance

Unscheduled Maintenance

Training

Transportation

Mid-Life Upgrade

- Each event generates demand for resources by time and location

- Times determined by lead times

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Database Design and Maintenance are Crucial

- To achieve accuracy, large amounts of data will be involved
- To achieve quick and responsive analytical capability, the data must be
  - Available
  - In the right form and format
  - Defined correctly for the specific analytical purpose
  - Easily updated
- These requirements imply a database
  - Whose establishment represents a significant investment
  - Correctly designed for analytical use
  - Embedded in the decision-maker's data infrastructure

Events Define Resource Requirements

System

A component is a member of a hardware breakdown structure

Hardware Component

Each activity type is described by an instance of an event

Data about resources are kept in

Resource Libraries

Skills	Tools	Shops	Parts
	-		
	-		
	-		
	-		

Non-Recurring Event 4

Manufacturing Event 3

Operating Event 2

Maintenance Event 1

Type (PM/CM/Opn)
Frequency (by Hr, Msn,Yr)
Duration (: e.g. Mct)
Echelon (LOR constraint)

Resource Costs

Hardware Component

The cost of each event is a function of the resources it consumes

Resource Use
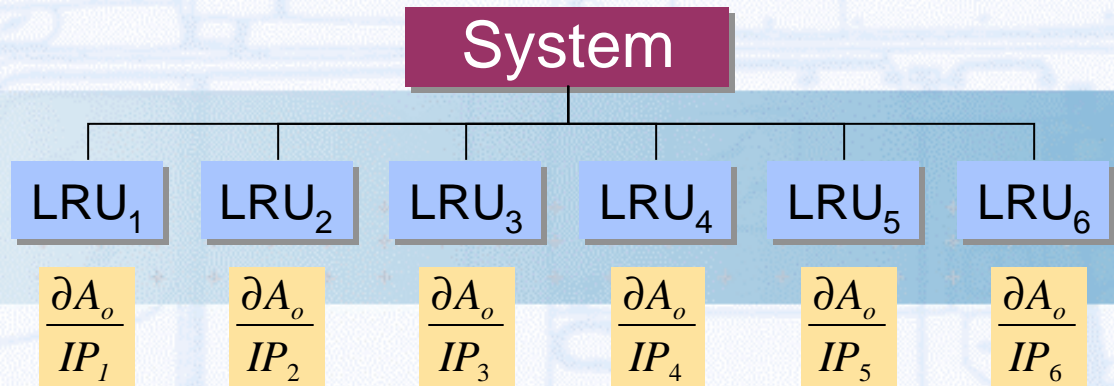**Resource Type**
Resource ID
Number Units
% of Duration
Probability of use

Courses

Books

Software

Total Ownership Cost by Event Type, Place, Resource and Time

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From Whole of Life Cost Analysis to Budget Management

- Resource-to-readiness mapping: how do costs create readiness?

- Accuracy required for both short- and medium-term estimates

- Quick turn-around for estimates (minutes or hours, not days)

- "What-if?" responsiveness

- ***Optimization would be nice…***
  - Which resources are causing costs
  - Which resources can be most easily divested
  - What sacrifice in operational capability is implied by a budget cut

How Optimization Works
Marginal Analysis

Step 1: Choose item with highest ratio

Step 2: Recompute ratio for that item

Step 3: Repeat steps 1 and 2 until target reached

System

| LRU$_1$ | LRU$_2$ | LRU$_3$ | LRU$_4$ | LRU$_5$ | LRU$_6$ |

$$\frac{\partial A_o}{IP_1} \quad \frac{\partial A_o}{IP_2} \quad \frac{\partial A_o}{IP_3} \quad \frac{\partial A_o}{IP_4} \quad \frac{\partial A_o}{IP_5} \quad \frac{\partial A_o}{IP_6}$$

**Summary Reports : 'Methods Illustration Run' run for 'Methods Illustration' project**

Reports

Ao vs Cost | By Part | By Site | Summary | System Structure | Net Benefit | Anomalies | Spares by Site | Summary by Site

Site Name	Item Name	Iter.	Total	Availability	Fill Rate	Total Cost	Slope
LHR	PRINTER	42	65	0.32190	0.17507	25232	2.50175E-06
LAX	PRINTER	43	66	0.32327	0.26849	25662	3.18097E-06
West Coast Shop	MODEM,MOD V.3225 RK	44	2	0.32509	0.26849	26094	4.20631E-06
DCA	PRINTER	45	67	0.32591	0.27500	26524	1.90889E-06
West Coast Shop	CPU BOARD	46	1	0.32851	0.27500	27523	2.59831E-06
DFW	PRINTER	47	68	0.32919	0.27782	27953	1.58488E-06
West Coast Shop	PRINTER	48	69	0.32980	0.28319	28208	2.38314E-06
West Coast Shop	SENSOR/COMM ASSY	49	1	0.34016	0.28319	30473	4.57505E-06
West Coast Shop	SENSOR/COMM ASSY	50	2	0.35052	0.28319	32738	4.57504E-06
West Coast Shop	SENSOR/COMM ASSY	51	3	0.36088	0.28319	35003	4.57501E-06
West Coast Shop	SENSOR/COMM ASSY	52	4	0.37124	0.28319	37268	4.57484E-06

The Multi-Resource Availability-for-Cost Curve
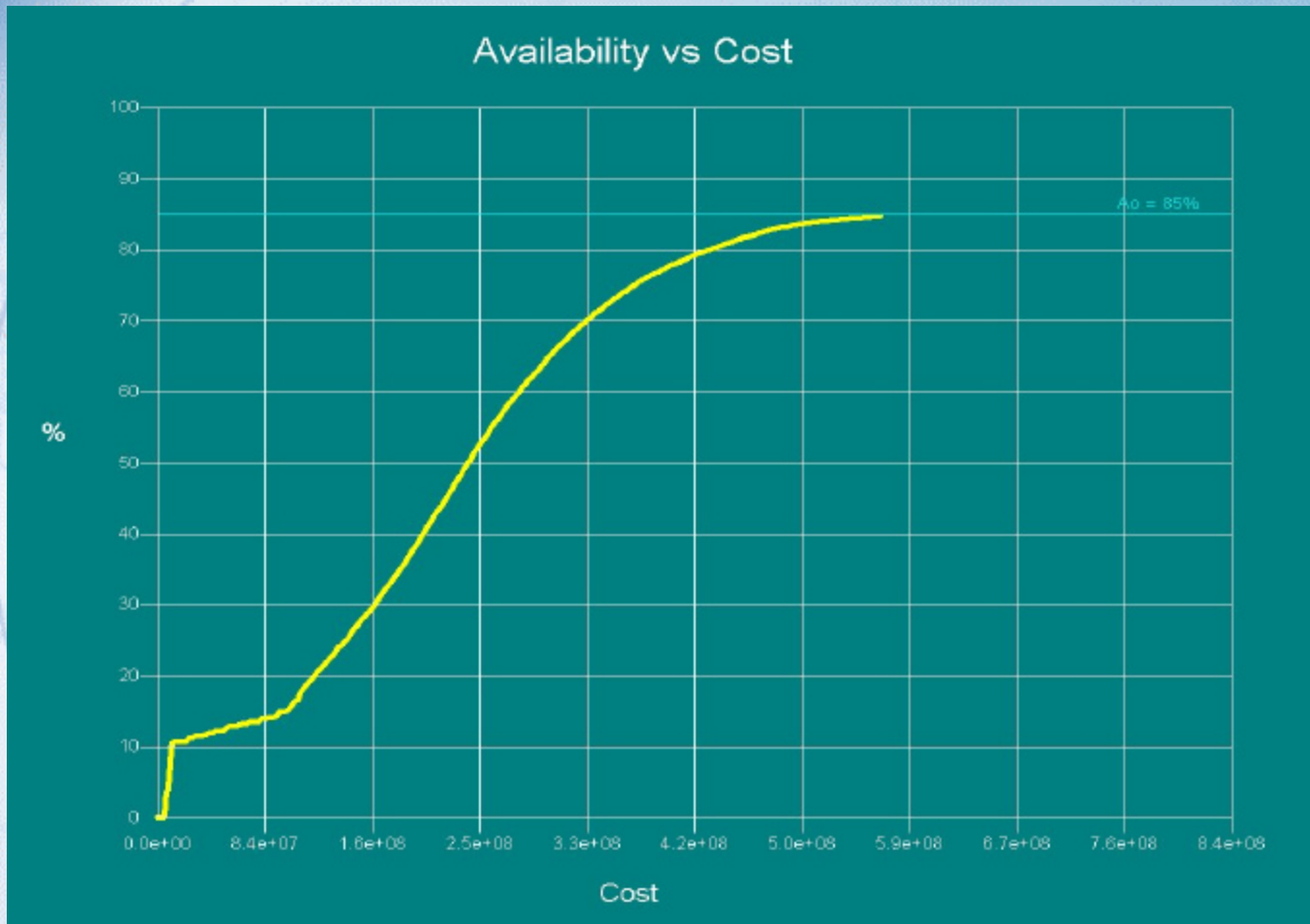
The Decision-Maker's Menu
Data Underlying the Multi-Resource Curve

Year	ResourceName	UnitName	Delta	Cost	DeltaPerDollar	RunningCost	Ao
2001	Assembly E4 type 1	Operating Unit 01	0.0069916613	44948.75	1.555474E-07	333618124.09	0.6927041456
2001	Assembly E6 type 2	Operating Unit 03	0.0496814467	319805.59375	1.553489E-07	333937929.68	0.6931743280
2001	Assembly E4 type2	Operating Unit 03	0.0464487146	299722.09375	1.549726E-07	334237651.77	0.6936204825
2001	Assembly E3 type 3	Operating Unit 03	0.0488565757	316171.4375	1.545256E-07	334553823.21	0.6940473056
2001	Assembly E4 type2	Operating Unit 01	0.0463056126	299722.09375	1.544952E-07	334853545.30	0.694369629
2001	Assembly E5 type 2	Operating Unit 03	0.0560656698	363415.4375	1.542743E-07	335216960.74	0.6949259358

- To reduce costs, back down the curve (I.e., move back up the list of resources)
  - Until the running cost has been reduced to the new budget level

- This provides the response that minimizes the operational sacrifice

Conclusions

- Mixed methods in current use represent traditional practice
  - Analysts know and believe in the methods
  - Decision-makers have learned to use particular methods and suspect all others

- Traditional methods were perfected before the recent emphasis on whole of life costs

- They do not satisfy the requirement to provide continuous, consistent decision data

- Event-driven methods, coupled with appropriate databases can

- MAAP is an example